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# **The effectiveness of using a simple ARIA based geographical classification to identify road crash patterns in rural and urban areas of Queensland**

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## **Abstract**

Research has noted a 'pronounced pattern of increase with increasing remoteness' of death rates in road crashes [1]. However, crash characteristics by remoteness are not commonly or consistently reported, with definitions of rural and urban often relying on proxy representations such as prevailing speed limit. The current paper seeks to evaluate the efficacy of the Accessibility / Remoteness Index of Australia (ARIA+) to identifying trends in road crashes. ARIA+ does not rely on road-specific measures and uses distances to populated centres to attribute a score to an area, which can in turn be grouped into 5 classifications of increasing remoteness. The current paper uses applications of these classifications at the broad level of Australian Bureau of Statistics' Statistical Local Areas, thus avoiding precise crash locating or dedicated mapping software. Analyses used Queensland road crash database details for all 31,346 crashes resulting in a fatality or hospitalisation occurring between 1st July, 2001 and 30th June 2006 inclusive. Results showed that this simplified application of ARIA+ aligned with previous definitions such as speed limit, while also providing further delineation. Differences in crash contributing factors were noted with increasing remoteness such as a greater representation of alcohol and 'excessive speed for circumstances.' Other factors such as the predominance of younger drivers in crashes differed little by remoteness classification. The results are discussed in terms of the utility of remoteness as a graduated rather than binary (rural/urban) construct and the potential for combining ARIA crash data with census and hospital datasets.

## **Keywords**

Remoteness, ARIA, geographic classification, rural, urban, crash factors

## **Introduction**

Epidemiological studies have frequently identified rural-urban differentials in terms of burden of disease and health outcomes [2]. When considering disadvantages stemming from location, a number of related factors which may typically fall outside the scope of the research field should be taken into account. Rural disadvantage may stem from a number of factors including geographic isolation, availability of services, lower socioeconomic status of residents or ethnicity [3]. For example, a rural culture of tolerance of risk and even fatalism towards injury has been suggested to contribute to a rural-urban differential in road crash involvement [4].

### *Road Crashes*

Road crashes continue to be a serious problem in terms of their contribution to social and financial costs, with a road fatality in Australia estimated to cost approximately \$2.2 million to society (in 2009 dollars) [5]. Relatively little attention however has been given to attempting to identify differences in road crashes as a direct result of the remoteness of the area in which they occur. This is despite the fact that road crashes are one of the most consistently identified areas in which rural people are shown to be disadvantaged in terms of relative mortality and morbidity. In fact, the Australian Institute of Health and Welfare (AIHW) has noted the '*pronounced pattern of increase with increasing remoteness*' of death rates from vehicle accidents [1, pvii]. Such statistics are however not unique to Australia, with the United States National Highway Traffic Safety Administration (NHTSA) reporting from a ten year review of fatal traffic crashes that "*there are approximately 35 percent more crashes, vehicles involved, individuals involved, and deaths in rural areas than in urban areas*" despite fewer relative miles travelled within these areas [6].

As a result of this, Rural and Remote populations have been recognised as a priority for injury prevention in the National Injury Prevention and Safety Promotion Plan, 2004-2014 [7], and the Australian National Road Safety Action Plan for 2008 and 2009 [8]. However, a meaningful and easily applicable method for the identification of crashes and contributing factors in rural areas is not often used. As Smith et al [2] note, there is a need for any grouping of rural and urban status to make a meaningful delineation in the context of the data being investigated.

#### *Methods to Identify Rural Road Crashes*

Rural differences in road crashes can be attributed in part to the nature of the people living and driving in the region as well as the road environment and driving conditions themselves. In the context of road crashes, there are characteristics specific to driving in rural as opposed to urban areas such as the predominance of higher speed limit zones, greater travel distances in terms of kilometres, less relative traffic density, and less road infrastructure (such as intersections, traffic control and turning lanes). As an example, it has been found that lower density areas in the U.S. state of Michigan are associated with a higher level of drink driving [9]. This can be due in part to a higher level of drinking in these rural areas, as well as a relative lack of alternative transport options. Any classification system used should attempt to take into account both these broad variables while capturing the nature of rural driving.

#### *Previous Classification Systems*

A number of methods have been used in road crash analyses to classify the nature of the location of crashes.

##### Speed Limits

One simple method is to class a crash as rural on the basis of it occurring on a stretch of road where the prevailing speed limit was equal to or above 100km/h. The Australian Federal Office of Road Safety (FORS), in comparing this speed limit method against a definition of 'rural' as roads outside of town boundaries reported an accuracy of 83%, with this accuracy being 89% for urban areas [FORS, 10]. Variations on this method have also been used which instead place the cut-off speed limit at 80km/h. These definitions are however problematic in that they classify freeways and major expressways around urban areas as 'rural.'

##### Urbanised Areas

The United States Fatality Analysis Reporting System (FARS) on the other hand defines rural crashes by exclusion from 'urban areas.' These 'urban areas' are defined as those within the boundaries of an 'urbanized area' with a population of 50,000 or more as designated by the U.S. Bureau of the Census, or areas with a population of 5,000 outside of these areas (i.e. - larger non-metropolitan towns). This definition thus takes into account the relative size of the population centres in which a crash may occur, but not necessarily the level of accessibility and service associated with distance from a major centre (i.e. a 'rural' road can be 10km outside of a small town with a greater than 5,000 population and 100km from an 'urbanized area', or 100km outside of a small town with no access to emergency services). Thus, such a method will likely over-estimate the number of crashes that might be anecdotally considered rural and provides no differentiation between regional, rural and remote areas [11, 12]. The same conclusion can also be drawn in regards to using a speed limit to determine rurality. In terms of reporting for Canadian road crashes, urban locations are defined as those on metropolitan roads and streets and other urban areas, or areas with a prevailing speed limit of 60km/h or less. Rural locations are then defined as primary or secondary highways, local roads, or areas where the speed limit exceeds 60km/h [13].

##### ARIA System

The ARIA (Accessibility/Remoteness Index of Australia) system was developed in 1997 to provide a geographical approach to the classification of remoteness. The system's classifications are based on distances calculated between any given point and the nearest large towns and major cities. In this respect, ARIA does not directly consider road safety specific aspects such as the quality of roads or travelling speeds. However, it takes into account factors such as the distance to major centres from which emergency services will be provided. Patterson [14] drew attention to the challenges posed by competing definitions of 'rural', with a suggestion that the ARIA classification system will facilitate comparisons both over time and between data sources. As an example, Queensland health data such as hospital

admissions are currently recorded against ARIA codes for both the usual residence of the patient and the location of the hospital or facility.

## **Method**

### *Data*

The current project used data for all serious crashes (resulting in a fatality or hospitalisation) occurring in the Australian state of Queensland for the period 1<sup>st</sup> July, 2001 to the 30<sup>th</sup> June 2006 inclusive. The data was extracted from the Queensland Road Crash Database with separate files at the levels of analysis of crash (pertaining to each incident), unit (pertaining to the vehicles, pedestrians and bicyclists involved in the crash), and casualties (the resulting injured people either travelling on, inside or as the unit in the crash). Data for a total of 31,346 crashes was available during this time period. This data was imported into the R statistical environment for management and analysis [15].

### *Rural Classification*

Location information was available in the provided data for each crash, including a variable for the statistical local area (SLA), a geographic grouping determined by the Australian Bureau of Statistics. Each SLA was matched to Australian Standard Geographic Classification (ASGC) ARIA+ data available as published by the Australian Institute of Health and Welfare [16]. Each SLA was assigned a remoteness category from 1 to 5 corresponding to the broad groups of Major Cities, Inner Regional, Outer Regional, Remote and Very Remote. Where an SLA was divided between two or more remoteness categories, it was assigned the category that constituted 60% or greater of the SLA. This categorisation scheme left only 11 of the 482 possible SLAs (2.3%) unassigned to a remoteness category, corresponding to 786 crashes out of a total of 31,346 (2.5%).

While this broad application of ARIA+ does not allow for an attribution of a remoteness figure to the exact location of the crash, it provides a good estimate on the basis of a relatively small geographic area while also not presenting a spurious level of accuracy.

### *Analysis*

A number of broad analyses were run to test the validity of the ARIA classification system, including checking the number of crashes occurring in each region as well as specific details of the crashes such as the prevailing speed limit, the time of day of crash, the presence of traffic control, the nature of the crash, the number of vehicles involved and the attribution of speed and alcohol as contributing factors.

## Results

Table 1 below shows the majority of crashes occurring in Major Cities. This data however also highlights the substantial number of fatal and hospitalisation crashes which occur in the Outer Regional to Very Remote areas, when taking into account the much lower proportion of population within this area.

**Table 1.** Serious crashes by severity and ARIA+ region.

ARIA+	Fatal	%	Hosp.	%	Serious	%	Qld Pop'n % <sup>a</sup>
Major Cities	577	32.3	14456	50.2	15033	49.2	60.0
Inner Regional	607	34.0	7133	24.8	7740	25.3	21.8
Outer Regional	462	25.9	5944	20.7	6406	20.9	14.9
Remote	86	4.8	702	2.4	788	2.6	2.0
Very Remote	53	2.9	540	1.9	593	1.9	1.2
<b>Total</b>	<b>1785</b>	<b>100.0</b>	<b>28775</b>	<b>100.0</b>	<b>30560</b>	<b>100.0</b>	<b>100.0</b>
Not classified	70	3.8	716	2.4	786	2.5	-

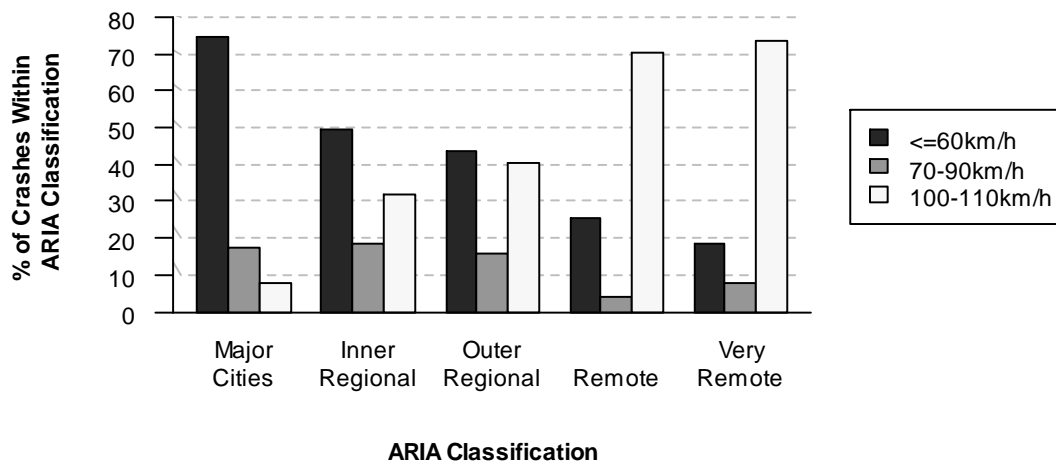
<sup>a</sup> - Source: Australian Bureau of Statistics, 2006 Census Data, CDATA Online [17]

The proportion of serious crashes resulting in a fatality increases gradually from Major Cities (3.8%), to Inner Regional (7.8%) and Outer Regional (7.2%) areas, to Remote (10.9%) and Very Remote areas (8.9%).

### Driving Environment

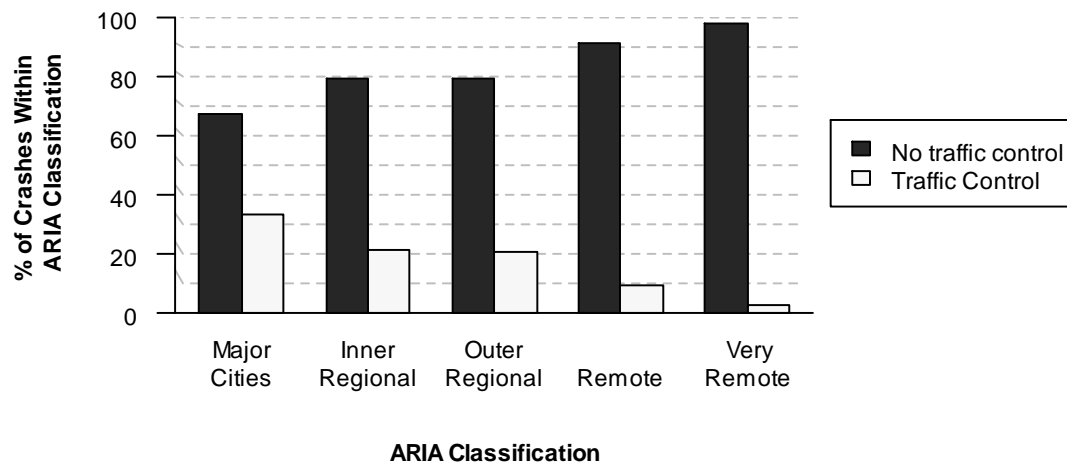
#### Speed Limit

The prevailing speed limit at which the crash occurred has been used previously as a proxy indicator of remoteness. As can be seen in Figure 1, the proportion of crashes in higher speed zones increases gradually as the ARIA remoteness indicator increases.

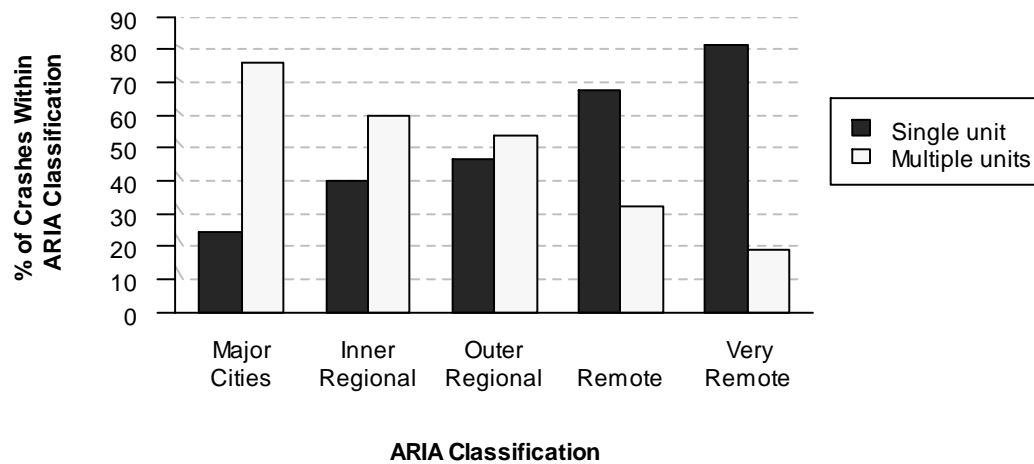


**Figure 1.** Crashes by prevailing speed limit and ARIA classification

Likewise, Figures 2 and 3 demonstrate the gradual change with increasing remoteness of the presence of traffic control and number of units involved in crashes.



**Figure 2.** Crashes by presence of traffic control and ARIA classification

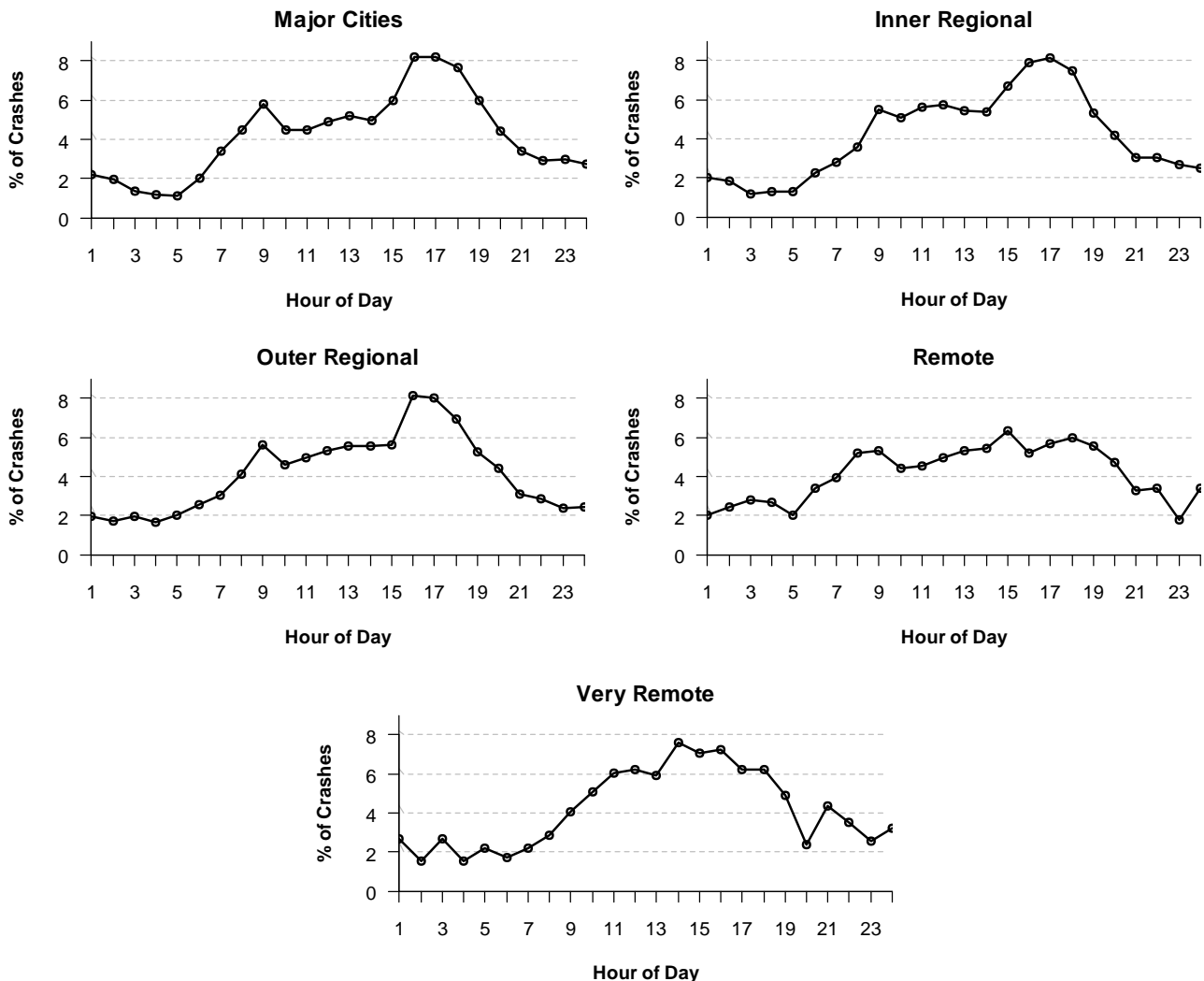


**Figure 3.** Crashes by number of crash units and ARIA classification

The differences in the road and traffic environments are thus captured by the distinct ARIA categories.

### Temporal Factors

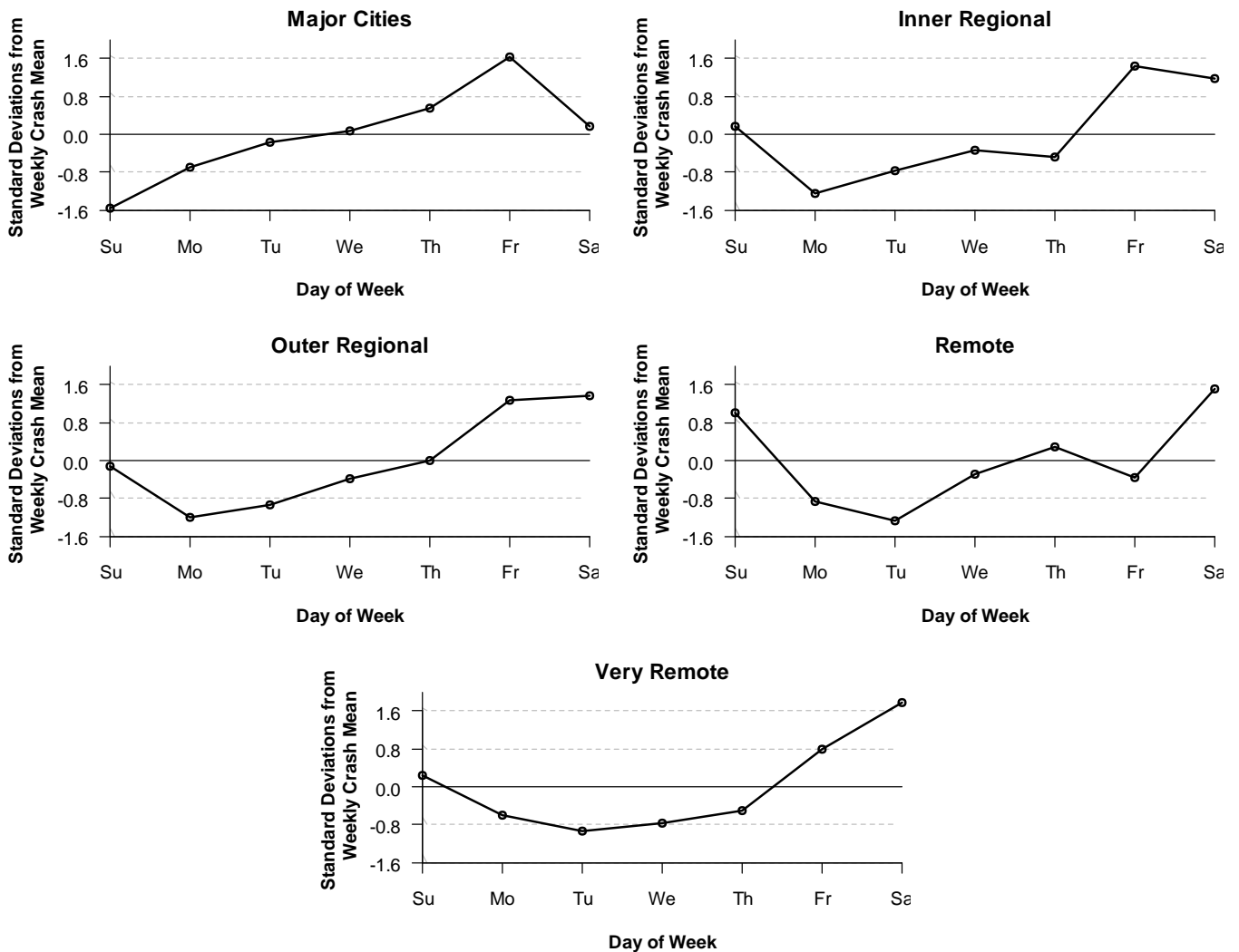
The time of day and day of week on which crashes occurred was also analysed by ARIA category as shown in Figure 4 below.



**Figure 4.** Crashes by hour of day and ARIA classification

As can be seen, the overall pattern of crashes across the day was similar between all ARIA categories, with the highest proportions of crashes being distributed across the hours of 6am to 8pm. An afternoon peak in crashes was however not identified in Remote locations as it was for the other ARIA classifications.

Figure 5 presents the comparative proportion of crashes occurring on each day by ARIA classification. An average daily number of crashes was calculated using the total number of crashes across the week within each ARIA classification. The number of actual crashes occurring on each day of the week was then compared to this figure, and a standard deviation from the average calculated.



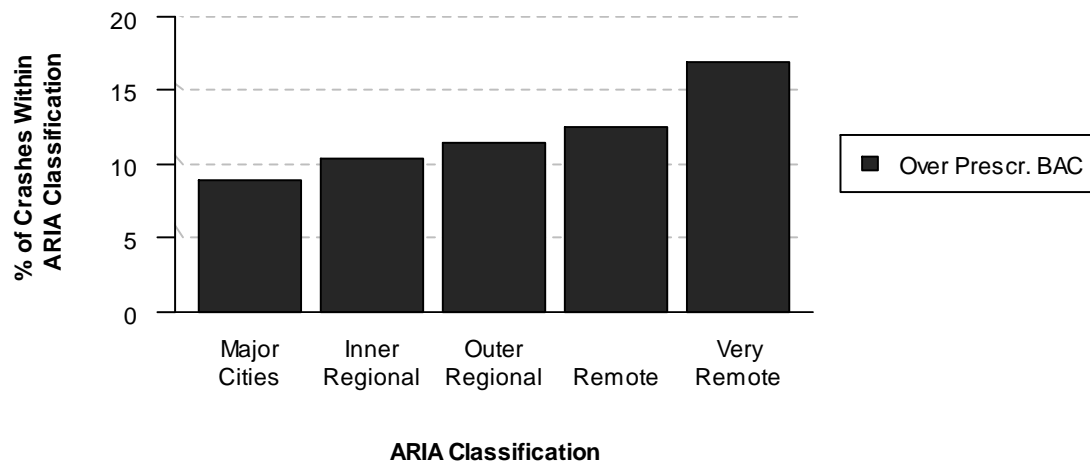
**Figure 5.** Crashes by day of week and ARIA classification

Peak crash periods were typically either on Friday or Saturday, or on both of these days together. The peak times of crashes did however show a number of differences across ARIA classifications. The majority of these differences lay between the Major Cities classification and the other classifications. The Major Cities classification had an above average number of crashes on Friday, which was also present in all other classifications except Remote. However, Saturday crashes were represented at well above average rates for all areas except Major Cities, which was unique to this classification. Sunday crashes represented a less than average number of crashes in Major Cities which was unique to this classification. These findings together suggest an overall reduced number of crashes on the weekend (Saturday and Sunday only) in Major Cities compared to other areas.



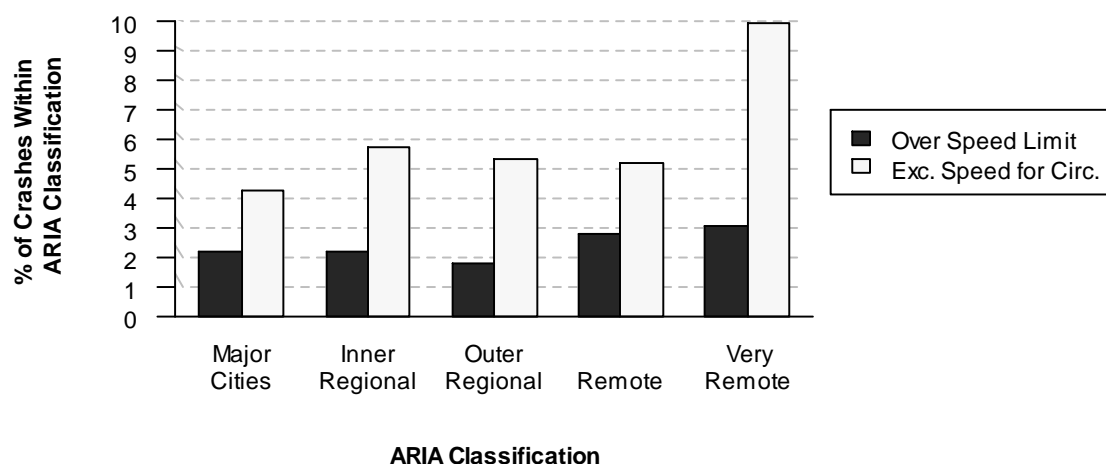
### Contributing crash circumstances

Contributing circumstances are listed for each unit (a car, motorcycle or pedestrian) involved in a crash. However, the following results refer to the particular circumstance being attributed to any unit in the crash. Figure 6 below presents the proportion of crashes where any unit controller (a driver, rider or pedestrian) was over the prescribed Blood Alcohol Concentration (BAC). This is typically 5gm/100mL (0.05 BAC) for fully licensed drivers, though zero BAC limits are imposed for young, novice and professional drivers in Queensland.



**Figure 6.** ‘Over prescribed BAC’ crashes by ARIA classification

As can be seen from the graph, the ARIA classifications capture the gradual increase in the contribution of alcohol to crashes with increasing remoteness. Of particular note is the substantial increase of alcohol affected road users in Very Remote areas.



**Figure 7.** ‘Exceeding speed limit’ and ‘Excessive speed for circumstances’ crashes by ARIA classification

Figure 7 does not show as clear a pattern of increasing contribution of excess travelling speed to crashes with increasing remoteness. There is however a definite increase in the proportion of ‘excessive speed for circumstance’ crashes in the Very Remote areas.

*Demographic Characteristics*

The gender and age group of at-fault unit controllers (drivers, riders or pedestrians, judged at fault by police reporting as 'Unit 1') across the 5 ARIA groups are shown in Tables 2a (males) and 2b (females) below.

**Table 2a.** At-fault crash units by age group and ARIA classification, males.

Age group (years)	MC		IR		OR		R		VR		All Areas
	%	All - MC	%	All - IR	%	All - OR	%	All - R	%	All - VR	%
0-16	1.1	<b>-0.4</b>	1.4	<b>0</b>	1.9	<b>0.4</b>	3.4	<b>1.9</b>	2.8	<b>1.3</b>	<b>1.4</b>
17-24	34.0	<b>1.9</b>	31.6	<b>-0.5</b>	29.1	<b>-2.9</b>	28.7	<b>-3.3</b>	29.9	<b>-3.1</b>	<b>32.1</b>
25-29	12.8	<b>0.4</b>	11.8	<b>-0.6</b>	12.3	<b>-0.1</b>	10.4	<b>-1.9</b>	16.6	<b>1.3</b>	<b>12.3</b>
30-39	19.2	<b>0.7</b>	16.9	<b>-1.6</b>	18.7	<b>0.2</b>	17.0	<b>-1.5</b>	21.7	<b>3.1</b>	<b>18.5</b>
40-49	13.1	<b>-0.9</b>	14.2	<b>0.2</b>	15.4	<b>1.4</b>	15.1	<b>1.2</b>	15.1	<b>1.2</b>	<b>13.9</b>
50-59	9.4	<b>-0.5</b>	10.4	<b>0.6</b>	9.9	<b>0.1</b>	12.3	<b>2.5</b>	8.3	<b>-1.5</b>	<b>9.8</b>
60-74	6.8	<b>-0.9</b>	8.8	<b>1.0</b>	8.4	<b>0.7</b>	9.5	<b>1.7</b>	8.1	<b>0.3</b>	<b>7.7</b>
75 and over	3.8	<b>-0.4</b>	5.0	<b>0.8</b>	4.4	<b>0.3</b>	3.6	<b>-0.6</b>	1.5	<b>-2.7</b>	<b>4.2</b>

**Table 2b.** At-fault crash units by age group and ARIA classification, females.

Age group (years)	MC		IR		OR		R		VR		All Areas
	%	All - MC	%	All - IR	%	All - OR	%	All - R	%	All - VR	%
0-16	0.6	<b>-0.4</b>	1.5	<b>0.5</b>	0.9	<b>0</b>	2.3	<b>1.4</b>	2.3	<b>1.3</b>	<b>0.9</b>
17-24	31.1	<b>0.6</b>	30.7	<b>0.2</b>	28.4	<b>-2.1</b>	33.8	<b>3.3</b>	31.3	<b>0.7</b>	<b>30.5</b>
25-29	11.4	<b>0.9</b>	8.2	<b>-2.2</b>	11.0	<b>0.6</b>	7.4	<b>-3.1</b>	14.8	<b>4.3</b>	<b>10.5</b>
30-39	18.5	<b>0.5</b>	15.9	<b>-2.1</b>	19.9	<b>1.9</b>	17.6	<b>-0.5</b>	15.9	<b>-2.1</b>	<b>18.1</b>
40-49	15.0	<b>0</b>	15.6	<b>-0.4</b>	15.3	<b>0.3</b>	15.7	<b>0.8</b>	15.9	<b>0.9</b>	<b>14.9</b>
50-59	11.0	<b>-0.9</b>	13.7	<b>1.7</b>	11.8	<b>-0.2</b>	12.9	<b>0.9</b>	13.6	<b>1.7</b>	<b>11.9</b>
60-74	8.1	<b>-0.7</b>	10.1	<b>1.3</b>	9.1	<b>0.3</b>	8.3	<b>-0.4</b>	6.3	<b>-2.5</b>	<b>8.8</b>
75 and over	4.4	<b>0</b>	5.3	<b>1.0</b>	3.6	<b>-0.8</b>	1.9	<b>-2.5</b>	0.0	<b>-4.3</b>	<b>4.3</b>

The pattern of a high proportion of crashes being attributable to young drivers aged between 17 and 24 years of age is shown for both genders across all ARIA classifications. The age distributions of crashes did not differ substantially overall between ARIA classifications within each gender. Percentages of crashes involving drivers of a particular age group within each classification differed only slightly to the overall mean percentage for all areas combined.

## Discussion

The relative ease of use of classifying road crashes into broad geographical categories has been shown in the current paper. The above analyses, though undertaken using only a broad classification scheme, appear to be able to detect a number of meaningful differences in crashes between the ARIA categorisations. Most noticeably, the changes in the driving environment of crashes in terms of speed limit, traffic control and the involvement of other vehicles paint a picture of a more distant, less-populated area with faster travelling speeds, commonly associated with rural driving.

The fact that a number of similarities were also noted in the data should also be acknowledged. The distribution of crashes across the hours of the day was similar in all remoteness categories, possibly associated with common peak travelling times which persist regardless of location. That is, proportionately speaking, wake and sleep patterns of people should not vary substantially regardless of where one resides and drives. Likewise, the high proportion of younger drivers involved in crashes as 'at-fault' unit-controllers reflects long term trend data which has consistently identified this group as the most at risk of crash involvement [18, 19].

One issue that remains to be solved from these analyses is at what point an area should be defined as 'rural'. In terms of associating rurality with higher posted speed limits, there appears to be a 'tipping point' between the 'Outer Regional' and 'Remote' areas associated with a sudden increase in crashes in 100km/hr or higher zones. This pattern is likewise reflected in a drop in crashes involving multiple vehicles or some form of traffic control. It could well be argued that the constructs of 'rural' and 'urban' are not and should not be clearly defined, but rather represented as a continuum of changing conditions. This however would not preclude the identification of trends associated with increasing remoteness. For instance, the identification of increasing alcohol involvement with increasing remoteness is a signal that this should be a point of intervention for rural communities.

A consistent, well-documented and readily available geographic classification scheme such as ARIA has widespread applicability for comparing the effects of interventions and programs that may have a differential effect on the basis of remoteness. One such example would be to consider the effect of late night driving and passenger restrictions introduced as part of a Graduated Licensing Scheme on younger drivers. The lack of alternative transport in rural areas has been noted as an issue which may reduce support for, compliance with, and ultimately the effectiveness of such restrictions [20]. Applying ARIA to crash data after the introduction of such countermeasures would allow the monitoring of broad trends without relying on specific, targeted studies. The basic SLA (Statistical Local Area) method used in the current paper is applicable to all states in Australia and could be applied to retrospective data with a minimal amount of statistical and administrative overhead.

An additional benefit of using a system such as ARIA to classify crashes is that it facilitates the use of linked comparison data to explore trends related to crashes. The Australian Bureau of Statistics (ABS) uses ARIA categories as part of their Australian Standard Geographical Classification's 'Remoteness Structure' [21]. Data is also available from the ABS for individual Statistical Local Areas (SLAs). In this way, population data, demographic information (including Indigenous status), and information regarding vehicle use can be associated and compared with crashes in a particular area. This is a particularly important benefit in light of being able to calculate rates of injury and establishing relative risks of driving in areas of differing remoteness. Definitive and accurate information on the relative rates of travel within broad geographic areas is however a key issue that needs to be resolved. Currently, the ABS is only able to provide vehicle use information broadly at a statewide level regarding distance travelled within and outside of capital cities [22]. Other information sources reported by remoteness and available through the ABS Census includes the 'Number of motor vehicles' in households which could also be considered for determining relative risks [23].

As stated in the introduction to this paper, Queensland Health hospital admissions data also reports the usual residence of the patient and the location of the hospital or facility against ARIA categories. The use of a separate and clearly defined source of transport-related injury data facilitates the identification of common trends and injury rates and any shortfalls in recording of crashes that may be associated with increasing remoteness. As noted in a paper published from the Queensland Rural and Remote Road Safety Study, the costs associated with transporting road trauma patients between hospitals are substantial [24]. Linking locations of road crashes with the corresponding burden of treatment at health facilities will assist in identifying where treatment facilities could be improved across a region.

## References

1. Strong, K., et al., *Health in Rural and Remote Australia*. 1998, Australian Institute of Health and Welfare: Canberra.
2. Smith, K.B., J.S. Humphreys, and M.G.A. Wilson, *Addressing the health disadvantage of rural populations: How does epidemiological evidence inform rural health policies and research?* Australian Journal of Rural Health, 2008. **16**: p. 56-66.
3. Dixon, J. and N. Welch, *Researching the rural-metropolitan health differential using the 'social determinants of health'*. Australian Journal of Rural Health, 2000. **8**: p. 254-260.
4. Sticher, G., *An investigation of attitudes towards risk factors, personal driving ability and road safety information among rural and remote road users*, in Brisbane. 2005: Conference of Australian Institutes of Transport Research.
5. Connelly, L.B. and R. Supangan, *The economic costs of road traffic crashes: Australia, states and territories*. Accident Analysis & Prevention, 2006. **38**(6): p. 1087-1093.
6. National Highway Traffic Safety Administration, *Contrasting Rural and Urban Fatal Crashes 1994-2003*. 2005, US Department of Transportation: Washington, DC.
7. National Public Health Partnership, *The National Injury Prevention and Safety Promotion Plan: 2004-2014*. 2004, NPHP: Canberra.
8. Australian Transport Council, *National Road Safety Action Plan, 2007 and 2008*. 2006, ATC: Canberra.
9. Meliker, J.R., et al., *Spatial analysis of alcohol-related motor vehicle crash injuries in southeastern Michigan*. Accident Analysis and Prevention, 2004. **36**: p. 1129-1135.
10. Federal Office of Road Safety, *Trends in Fatal Crashes on Rural Roads*. 1995, Federal Office of Road Safety: Canberra.
11. Committee on Motor Vehicle Traffic Accident Classification, *Manual on Classification of Motor Vehicle Traffic Accidents*. 1997, National Safety Council: Itasca.
12. Office of the Law Revision Counsel. *Title 23 - Highways*. 2007 [cited 2009 18th February]; Available from: [http://uscode.house.gov/uscode-cgi/fastweb.exe?getdoc+uscview+t21t25+3974+29++\(\)\)%20%20AND%20\(\(23\)%20ADJ%20USC\)%3ACITE](http://uscode.house.gov/uscode-cgi/fastweb.exe?getdoc+uscview+t21t25+3974+29++())%20%20AND%20((23)%20ADJ%20USC)%3ACITE).
13. Transport Canada, *Canadian Motor Vehicle Traffic Collision Statistics 2006*. 2007, Transport Canada: Ottawa.
14. Patterson, C., *The emergence of rural health research in Australia*. Australian Journal of Rural Health, 2000. **8**: p. 280-285.
15. R Development Core Team, *R: A Language and Environment for Statistical Computing*. 2008, R Foundation for Statistical Computing: Vienna.
16. Australian Institute of Health and Welfare, *Rural, Regional and Remote Health: A Guide to Remoteness Classifications*. 2004, AIHW: Canberra.
17. Australian Bureau of Statistics. *CData Online*. 2009 [cited 2009 9th September]; Available from: <http://www.abs.gov.au/CDataOnline>.
18. Jonah, B.A., *Accident risk and risk-taking behaviour among young drivers*. Accident Analysis & Prevention, 1986. **18**: p. 255-271.
19. Ferguson, S.A., E.R. Teoh, and A.T. McCartt, *Progress in teenage crash risk during the last decade*. Journal of Safety Research, 2007. **38**: p. 137-145.
20. University of North Carolina Highway Safety Research Center, *The North Carolina Graduated Driver Licensing System: Urban - Rural Differences*. 2001, University of North Carolina Highway Safety Research Center: Chapel Hill.
21. Australian Bureau of Statistics. *Australian Standard Geographical Classification*. 2007 [cited; Available from: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1216.0Jul%202007?OpenDocument>.
22. Australian Bureau of Statistics. *Survey of Motor Vehicle Use, Australia, 12 months ended 31 Oct 2007*. 2008 [cited; Available from: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9208.012%20months%20ended%2031%20Oct%202007?OpenDocument>.
23. Australian Bureau of Statistics. *Census Data*. 2009 [cited 2009 26th February]; Available from: <http://abs.gov.au/websitedbs/D3310114.nsf/home/Census+data>.
24. O'Connor, T., et al., *The medical and retrieval costs of road crashes in rural and remote northern Queensland, 2004-2007: findings from the Rural and Remote Road Safety Study*. Medical Journal of Australia, 2009. **190**: p. 54-56.